

Clinical Olfactory Event-Related Potentials

Manual for data analysis

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To download:

- Letswave software to analyze EEG data in MatLab

<https://nocions.github.io/letswave6/>

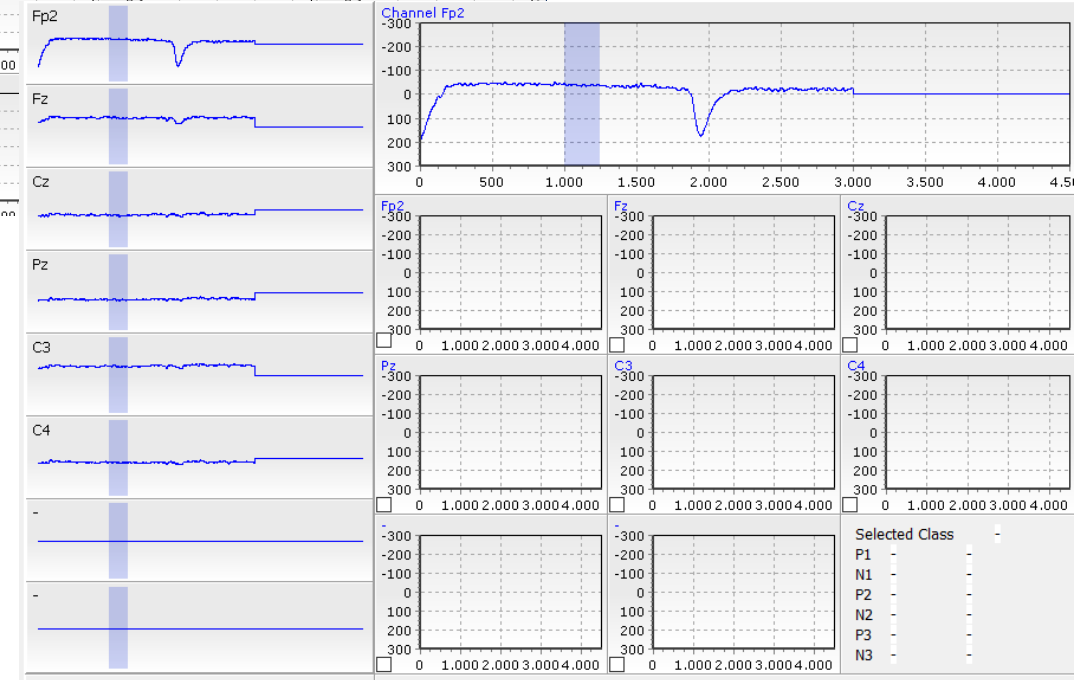
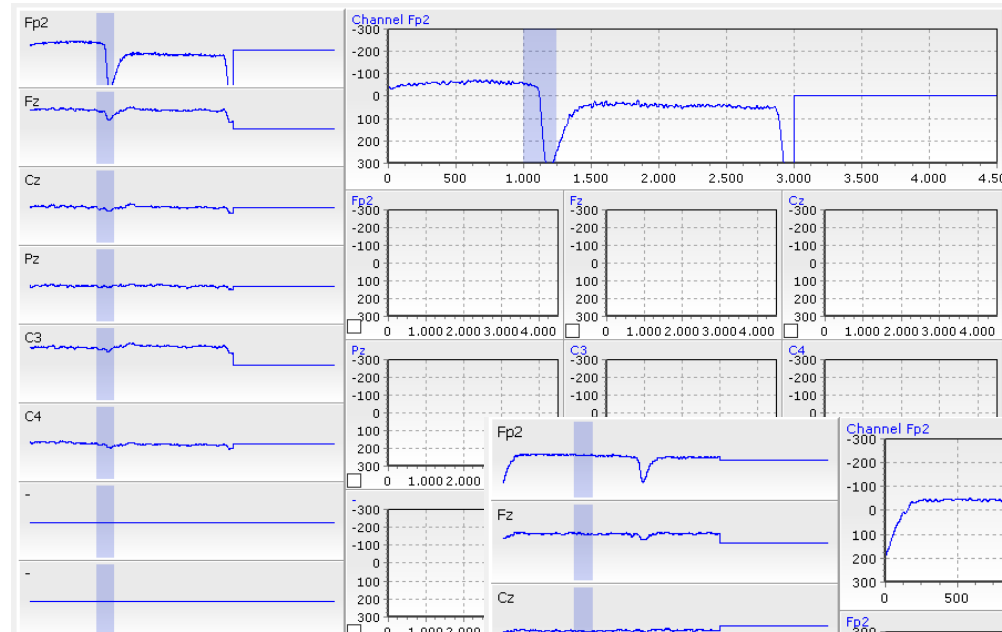
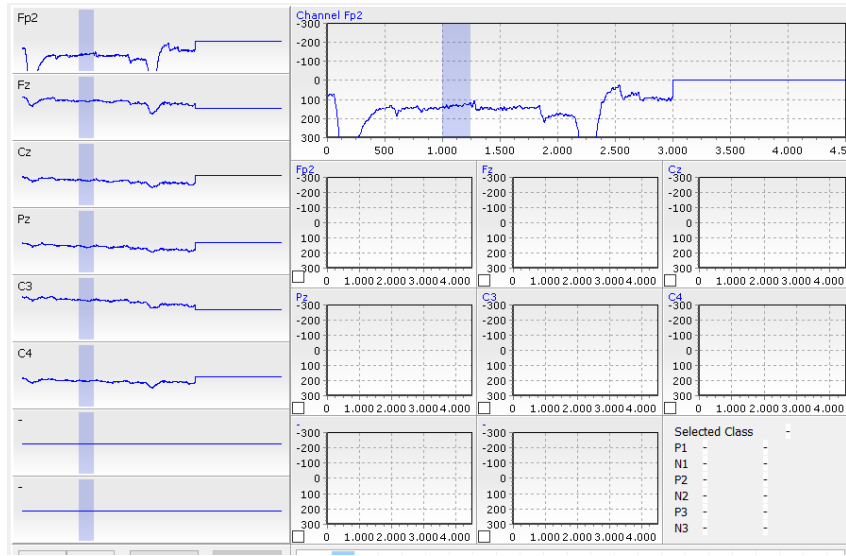
- Letswave scripts with the analysis pipeline
 - Script 1 – for event-related potentials
 - Script 2 – for time-frequency analysis
- Template to report results in .pptx

https://osf.io/5za3y/?view_only=6998f2aa50ea4e27ac5a8f3e75d6cf1c

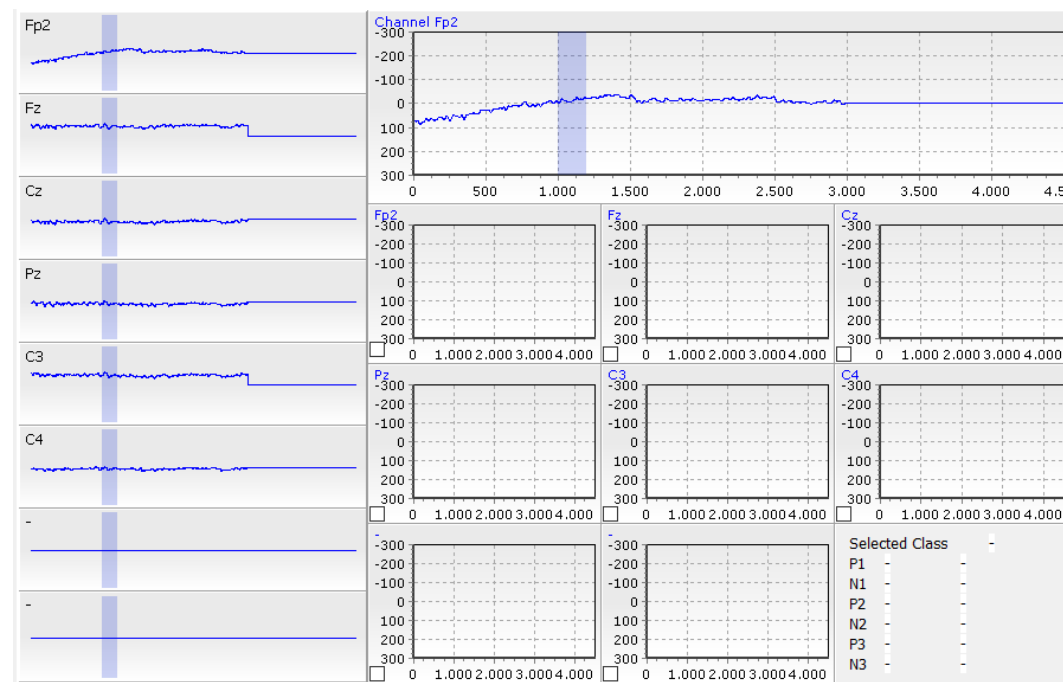
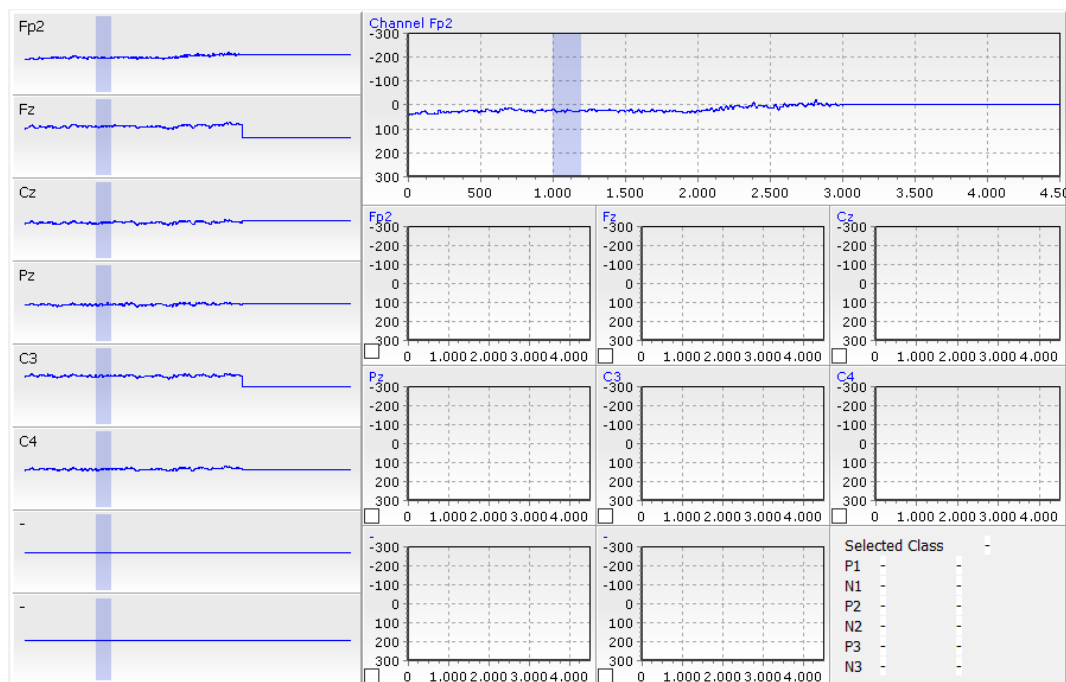
1. Epochs selection

- Each recorded epoch needs to be visually inspected for potential eye-blinks or other types of artifacts.
- Epochs containing artifacts should not be included in the analysis.
- Final number of epochs used for analysis should be recorded.

Examples of artifacts / eye-blinks (to be excluded)

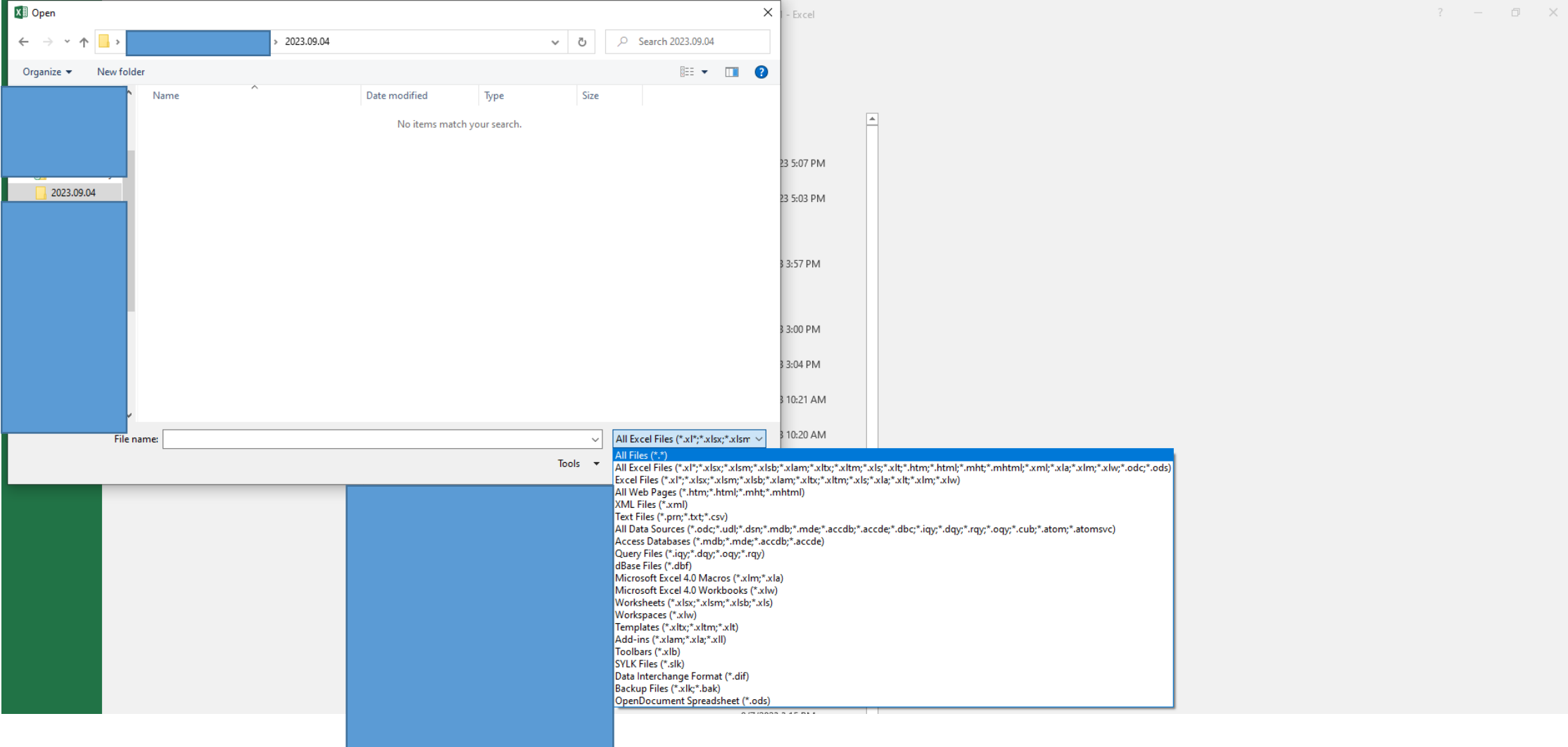


Examples of artifact-free signal (good for analysis)

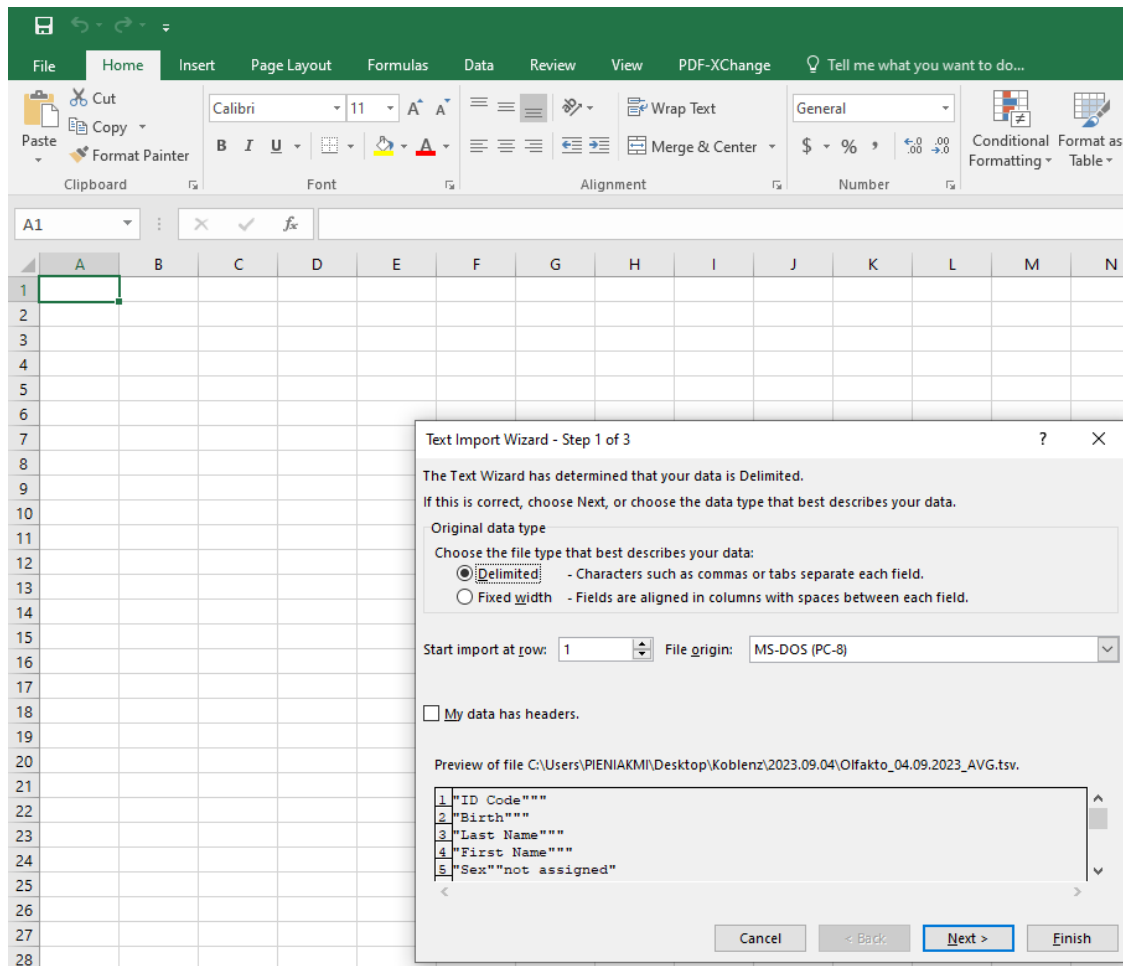


2. Preparing the dataset for analysis

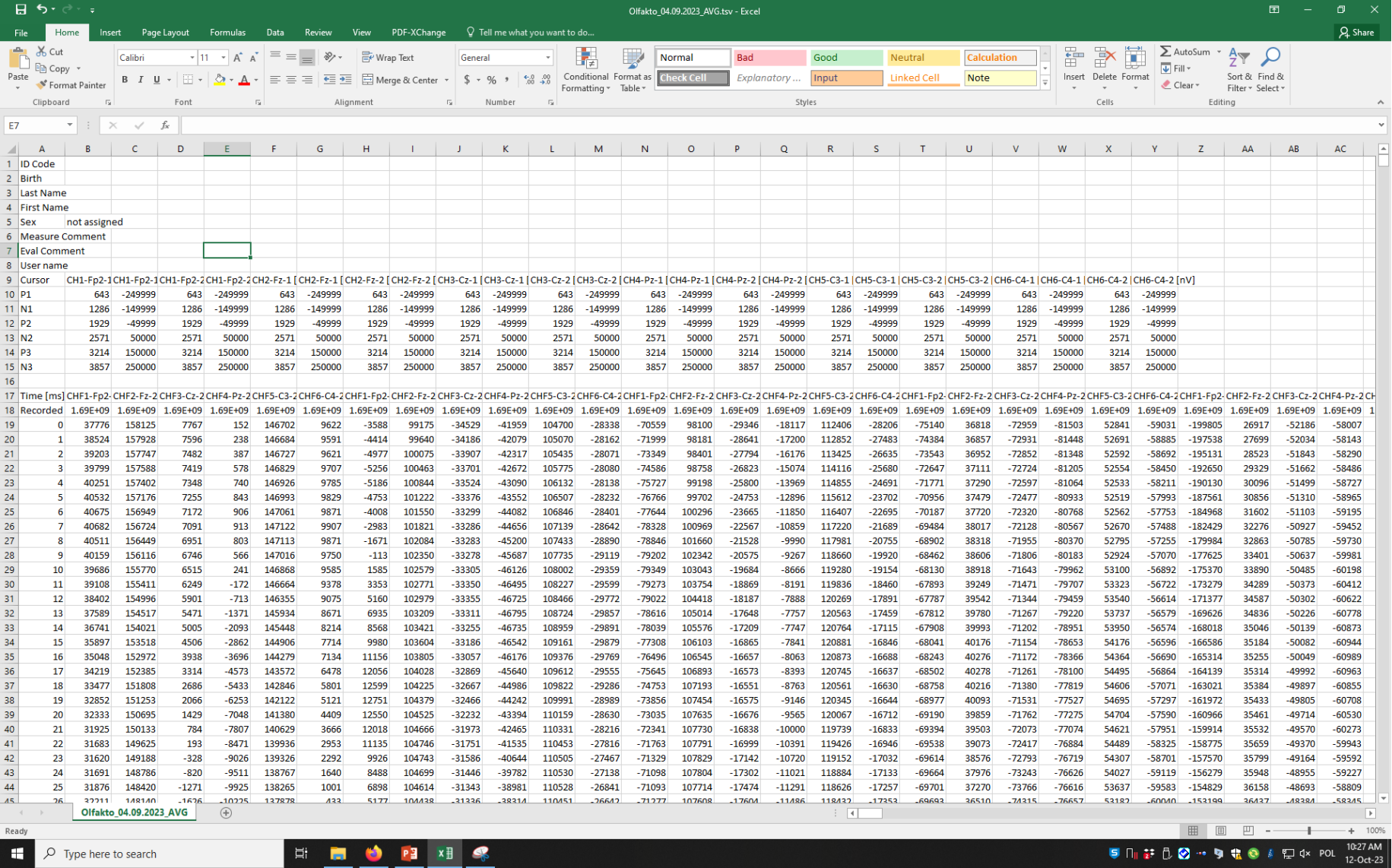
- The original dataset is saved in .tsv file.
- First the dataset should be open in Excel for cleaning



- To find .tsv files – select All files



- Click Finish



File

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Tell me what you want to do...

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11

General

Normal

Bad

Good

Neutral

Calculation

Check Cell

Explanatory ...

Input

Linked Cell

Note

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AutoSum

Fill

Clear

Sort & Find & Filter

Select

Clipboard

Font

Alignment

Number

Styles

Cells

Editing

VB17

CHF3-Cz-1-96 [nV]

	UO	UP	UQ	UR	US	UT	UU	UV	UW	UX	UY	UZ	VA	VB	VC	VD	VE	VF	VG	VH	VI	VJ	VK	VL	VM	VN	VO	VP	VQ
1																													
2																													
3																													
4																													
5																													
6																													
7																													
8																													
9																													
10																													
11																													
12																													
13																													
14																													
15																													
16																													
17	CHF2-Fz-1	CHF3-Cz-1	CHF4-Pz-1	CHF5-C3-1	CHF6-C4-1	CHF1-Fp2	CHF2-Fz-1	CHF3-Cz-1	CHF4-Pz-1	CHF5-C3-1	CHF6-C4-1	CHF1-Fp2	CHF2-Fz-1	CHF3-Cz-1	CHF4-Pz-1	CHF5-C3-1	CHF6-C4-1	AVF1-Fp2	AVF2-Fz-1	AVF3-Cz-1	AVF4-Pz-1	AVF5-C3-1	AVF6-C4-1	AVF1-Fp2	AVF2-Fz-2	AVF3-Cz-2	AVF4-Pz-2	AVF5-C3-2	AVF6-C4-2
18	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09
19	11773	39822	45827	26854	-20674	48301	-7566	1218	6824	-22407	-43323	246937	79484	73404	53325	44893	15812	-11609	32100	1762	13529	38726	-18564	2620	45355	5933	16864	54133	-7614
20	9379	37220	43077	24401	-23060	49542	-5958	2959	8826	-20566	-41668	247168	80036	73887	53788	45387	16331	-11562	32076	1729	13485	38702	-18607	2372	45280	5898	16862	54085	-7644
21	6611	34306	40060	21611	-25731	50701	-4484	4567	10702	-18854	-40134	247406	80693	74487	54388	46022	16932	-11507	32045	1686	13433	38668	-18655	2132	45197	5850	16843	54029	-7691
22	3541	31163	36850	18560	-28628	51758	-3164	6024	12426	-17296	-38732	247597	81403	75159	55075	46744	17563	-11448	32006	1635	13375	38628	-18706	1908	45111	5792	16811	53967	-7753

- In the last columns, the labels are starting with AVF and not CHF. The AVF columns represent the averaged signal from the 6 locations (Fp2, Fz, Cz, Pz, C3, C4) for the two stimuli (in total 12 columns).
- We want to keep only the AVF columns.

FileHomeInsertPage LayoutFormulasDataReviewViewPDF-XChangeTell me what you want to do...

CutCopyFormat PainterClipboardFontAlignmentNumberFormattingTableConditional Format

NormalBadGoodNeutralCalculationCheck CellExplanatory...InputLinked CellNote

InsertDeleteFormatAutoSumFillSort & Find & Filter

ClipboardFontAlignmentNumberStylesCellsEditing

VE1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC		
1	ID Code																														
2	Birth																														
3	Last Name																														
4	First Name																														
5	Sex	not assigned																													
6	Measure Comment																														
7	Eval Comment																														
8	User name																														
Cursor	CH1-Fp2-1	CH1-Fp2-1	CH1-Fp2-2	CH1-Fp2-2	CH2-Fz-1	CH2-Fz-1	CH2-Fz-2	CH2-Fz-2	CH3-Cz-1	CH3-Cz-1	CH3-Cz-2	CH3-Cz-2	CH4-Pz-1	CH4-Pz-1	CH4-Pz-2	CH5-C3-1	CH5-C3-1	CH5-C3-2	CH5-C3-2	CH6-C4-1	CH6-C4-1	CH6-C4-2	CH6-C4-2	[nV]							
P1	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999	643	-249999							
N1	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999	1286	-149999							
P2	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999	1929	-49999							
N2	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000	2571	50000							
P3	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000	3214	150000							
N3	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000	3857	250000							
16																															
Time [ms]	CH1-Fp2-1	CH2-Fz-2	CH3-Cz-2	CH4-Pz-2	CH5-C3-2	CH6-C4-2	CH1-Fp2-1	CH2-Fz-2	CH3-Cz-2	CH4-Pz-2	CH5-C3-2	CH6-C4-2	CH1-Fp2-1	CH2-Fz-2	CH3-Cz-2	CH4-Pz-2	CH5-C3-2	CH6-C4-2	CH1-Fp2-1	CH2-Fz-2	CH3-Cz-2	CH4-Pz-2	CH5-C3-2	CH6-C4-2	CH1-Fp2-1	CH2-Fz-2	CH3-Cz-2	CH4-Pz-2	CH5-C3-2	CH6-C4-2	
Recorded	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	1.69E+09	
0	37776	158125	7767	152	146702	9622	-3588	99175	-34529	-41959	104700	-28338	346	-18117	112406	-28206	-75140	36818	-72959	-81503	52841	-59031	-199805								
1	38524	157928	7596	238	146684	9591	-4414	99640	-34186	-42079	105070	-28162	641	-17200	112852	-27483	-74384	36857	-72931	-81448	52691	-58885	-197538								
2	39203	157747	7482	387	146727	9621	-4977	100075	-33907	-42317	105435	-28071	794	-16176	113425	-26635	-73543	36952	-72852	-81348	52592	-58692	-195131								
3	39799	157588	7419	578	146829	9707	-5256	100463	-33701	-42672	105775	-28080	823	-15074	114116	-25680	-72647	37111	-72724	-81205	52554	-58450	-192650								
4	40251	157402	7348	740	146926	9785	-5186	100844	-33524	-43090	106132	-28138	800	-13969	114855	-24691	-71771	37290	-72597	-81064	52533	-58211	-190130								
5	40532	157176	7255	843	146993	9829	-4753	101222	-33376	-43552	106507	-28232	753	-12896	115612	-23702	-70956	37479	-72477	-80933	52519	-57993	-187561								
6	40675	156949	7172	906	147061	9871	-4008	101550	-33299	-44082	106846	-28401	-77644	100296	-23665	-11850	116407	-22695	-70187	37720	-72320	-80768	52562	-57753	-184968						
7	40682	156724	7091	913	147122	9907	-2983	101821	-33286	-44656	107139	-28642	-78328	100969	-22567	-10859	117220	-21689	-69484	38017	-72128	-80567	52670	-57488	-182429						
8	40511	156449	6951	803	147113	9871	-1671	102084	-33283	-45200	107433	-28890	-78846	101660	-21528	-9990	117981	-20755	-68902	38318	-71955	-80370	52795	-57255	-179984						
9	40159	156116	6746	566	147016	9750	-113	102350	-33278	-45687	107735	-29119	-79202	102342	-20575	-9267	118660	-19920	-68462	38606	-71806	-80183	52924	-57070	-177625						
10	39686	155770	6515	241	146868	9585	1585	102579	-33305	-46126	108002	-29359	-79349	103043	-19684	-8666	119280	-19154	-68130	38918	-71643	-79962	53100	-56892	-175370						
11	39108	155411	6249	-172	146664	9378	3353	102771	-33350	-46495	108227	-29599	-79273	103754	-18869	-8191	119836	-18460	-67893	39249	-71471	-79707	53323	-56722	-173279						

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NormalBadGoodNeutralCalculationCheck CellExplanatory...InputLinked CellNote

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ClipboardFontAlignmentNumberStylesCellsEditing

S19

	A	B	C	D
1				
2				
3				
4				
5				

• Select all columns except the AVF columns and delete them

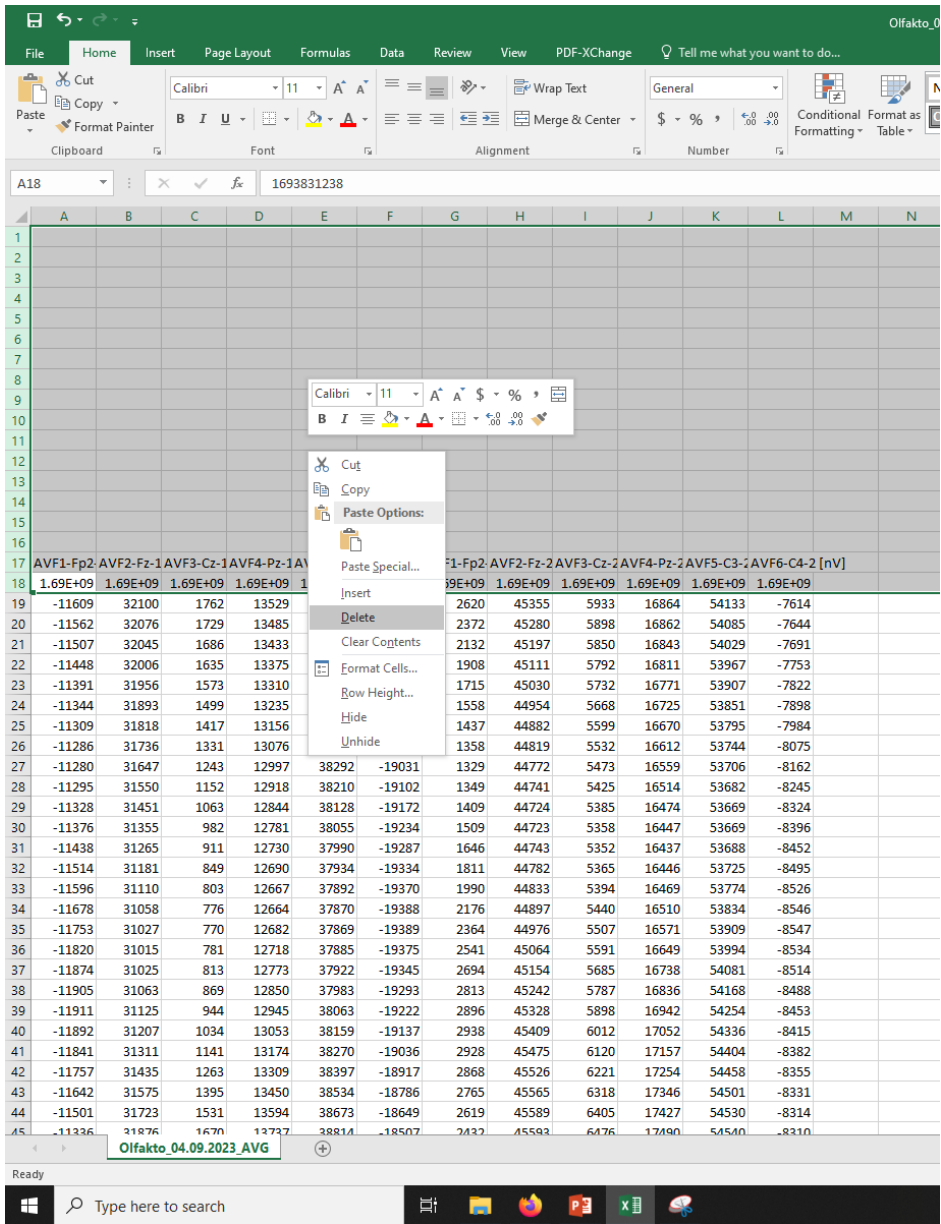
Afterwards the dataset should look like that →

0p2-C
105
138
150
161
168
184
192
197

FileHomeInsertPage LayoutFormulasDataReviewViewPDF-XChangeTell me what you want to do...

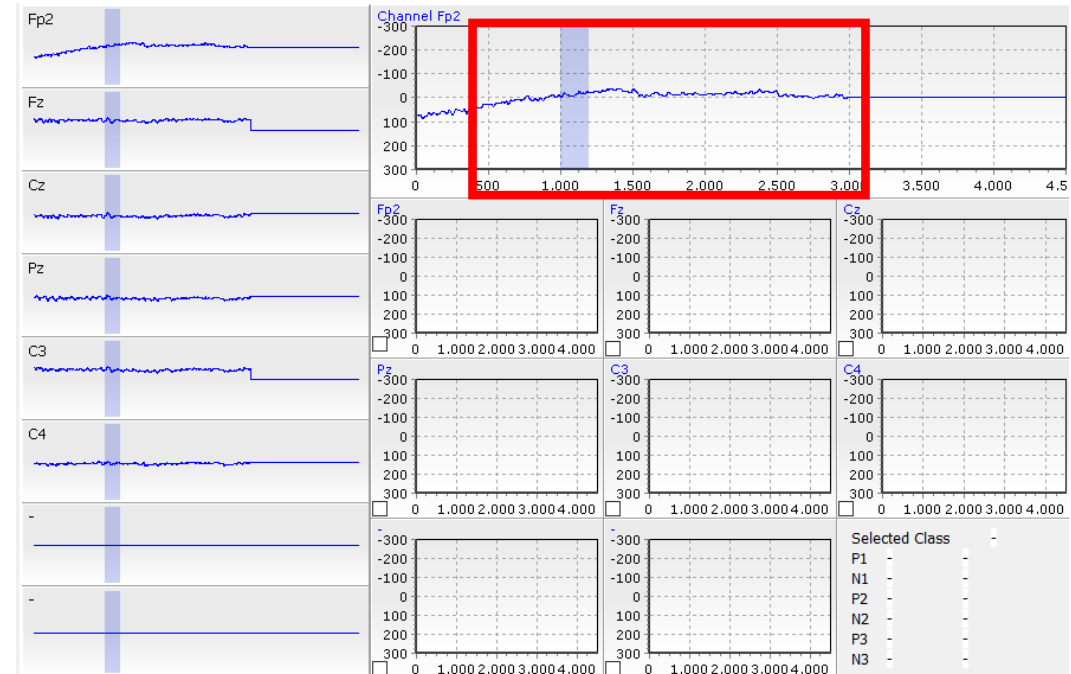
Calibri11A⁺

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- We now remove the first row (including headers) so only the raw data stays in the file

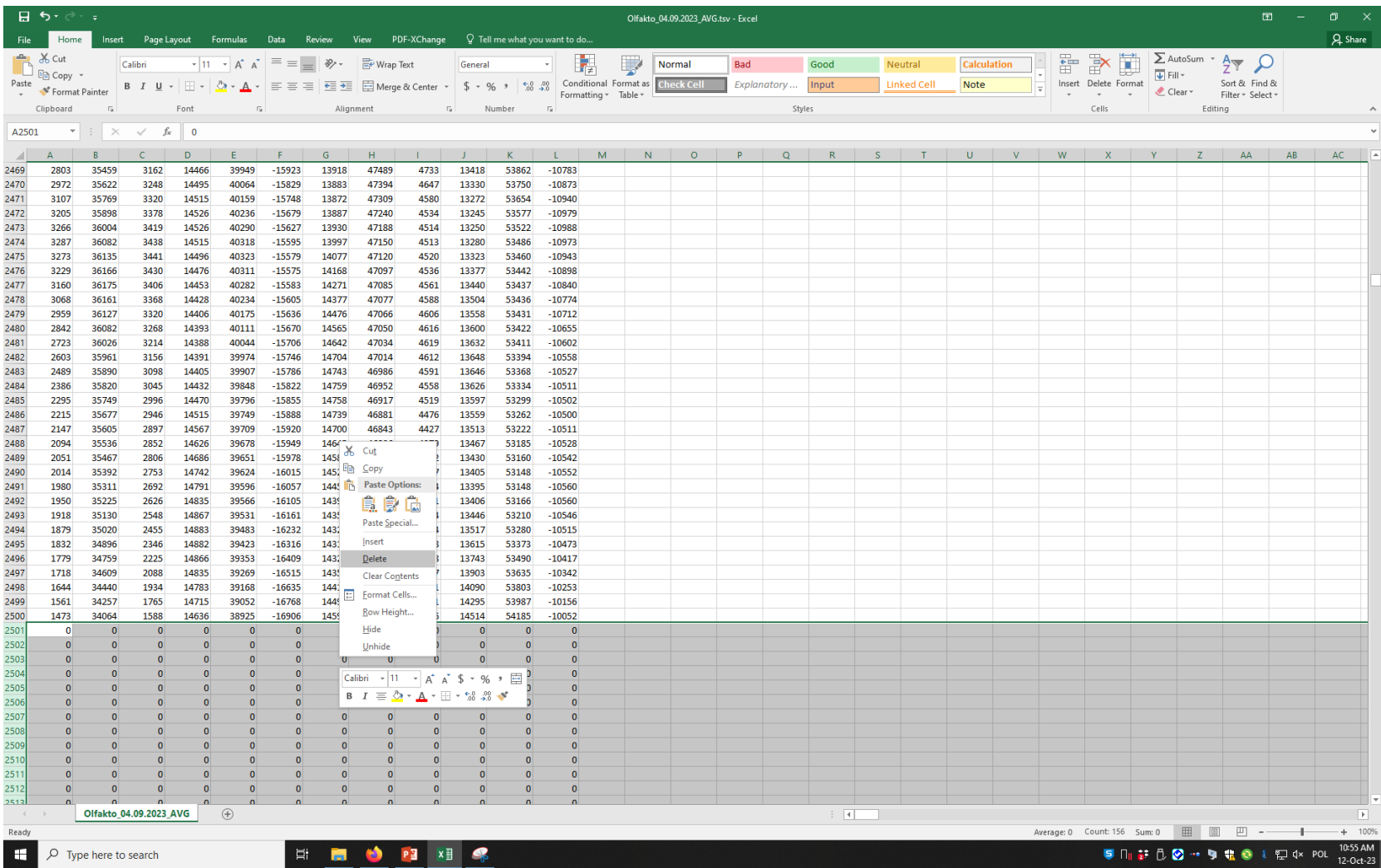
- Now, we have all the raw data, but for the analysis we want to keep only 500 ms before the stimulus onset and 2000 ms after the stimulus onset. All the remaining data should be removed.
- How much data should be removed depends on your olfactometer and amplifier settings (some hardware records 1000 ms before the onset, some more; that's the same for the recording afterwards)
- In the example below - first 500 ms and all the signal after 2000 ms post stimulus onset should be removed



The screenshot displays the Microsoft Excel application window. The title bar indicates the file is 'Oifakto_04.09.2023_AVG.tsv - Excel'. The ribbon is set to the 'Home' tab, showing options for Font, Paragraph, Styles, Cells, and Editing. A large data table is visible, spanning from column A to column AC and rows 457 to 500. The cell A500 is selected, and a right-click context menu is open, showing options like Cut, Copy, Paste, Paste Options, Paste Special..., Insert, Delete, Clear Contents, Format Cells..., Row Height..., Hide, and Unhide. The status bar at the bottom shows 'Ready', 'Average: 14521.86932', 'Count: 528', 'Sum: 7667547', and '10:53 AM 12-Oct-23'.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
457	-4108	33438	1383	13175	38255	-17759	-4640	44486	6346	16017	55024	-8873																	
458	-4103	33413	1309	13034	38189	-17875	-4683	44435	6302	15914	54936	-8940																	
459	-4101	33380	1226	12876	38118	-18008	-4717	44390	6266	15828	54860	-8998																	
460	-4100	33341	1141	12707	38049	-18149	-4734	44358	6246	15768	54807	-9039																	
461	-4099	33298	1054	12532	37982	-18298	-4723	44350	6252	15743	54789	-9056																	
462	-4104	33247	966	12353	37918					15756	54809	-9045																	
463	-4111	33193	883	12180	37861					15807	54868	-9007																	
464	-4119	33138	811	12020	37818					15902	54970	-8941																	
465	-4129	33083	750	11878	37789					15902	54970	-8941																	
466	-4145	33027	701	11757	37774					15902	54970	-8941																	
467	-4166	32972	669	11665	37777					15902	54970	-8941																	
468	-4190	32921	656	11608	37800					15902	54970	-8941																	
469	-4222	32873	659	11585	37842					15902	54970	-8941																	
470	-4263	32825	676	11595	37898					15902	54970	-8941																	
471	-4313	32778	707	11642	37969					15902	54970	-8941																	
472	-4371	32734	753	11724	38054					15902	54970	-8941																	
473	-4437	32690	807	11838	38149					15902	54970	-8941																	
474	-4515	32642	864	11975	38245					15902	54970	-8941																	
475	-4604	32590	922	12133	38340					15902	54970	-8941																	
476	-4700	32537	978	12305	38433					15902	54970	-8941																	
477	-4804	32477	1027	12485	38516					15902	54970	-8941																	
478	-4917	32409	1063	12662	38583					15902	54970	-8941																	
479	-5037	32332	1085	12829	38630					15902	54970	-8941																	
480	-5158	32249	1091	12983	38659	-18783	-942	47259	9141	19433	58360	-6410																	
481	-5278	32159	1079	13115	38664	-18735	-1062	47165	9029	19359	58231	-6470																	
482	-5398	32059	1046	13218	38642	-18705	-1247	47018	8863	19219	58033	-6579																	
483	-5513	31952	994	13288	38593	-18692	-1497	46818	8641	19011	57765	-6738																	
484	-5617	31842	928	13327	38523	-18695	-1799	46576	8376	18743	57439	-6942																	
485	-5707	31732	848	13332	38431	-18713	-2137	46303	8078	18428	57069	-7178																	
486	-5784	31621	757	13303	38320	-18750	-2498	46008	7755	18073	56665	-7441																	
487	-5842	31515	663	13244	38197	-18800	-2871	45698	7415	17687	56234	-7727																	
488	-5873	31421	572	13162	38070	-18856	-3238	45386	7072	17284	55795	-8023																	
489	-5879	31340	488	13060	37942	-18918	-3578	45091	6742	16883	55367	-8312																	
490	-5858	31274	415	12944	37819	-18983	-3876	44821	6434	16494	54960	-8588																	
491	-5808	31228	361	12823	37708	-19044	-4124	44582	6153	16126	54584	-8846																	
492	-5726	31209	334	12708	37619	-19093	-4305	44384	5913	15793	54252	-9073																	
493	-5613	31215	335	12603	37555	-19129	-4406	44240	5725	15511	53981	-9255																	
494	-5474	31246	365	12515	37517	-19150	-4421	44154	5593	15287	53775	-9390																	
495	-5310	31305	427	12451	37510	-19152	-4351	44122	5515	15123	53633	-9476																	
496	-5119	31392	525	12418	37540	-19129	-4194	44148	5496	15025	53561	-9510																	
497	-4909	31505	654	12417	37602	-19083	-3949	44234	5537	14999	53563	-9485																	
498	-4688	31637	808	12449	37694	-19017	-3626	44373	5634	15041	53632	-9405																	
499	-4459	31786	986	12514	37813	-18930	-3241	44553	5774	15144	53756	-9281																	
500	-4227	31948	1182	12613	37956	-18822	-2804	44766	5953	15303	53929	-9115																	

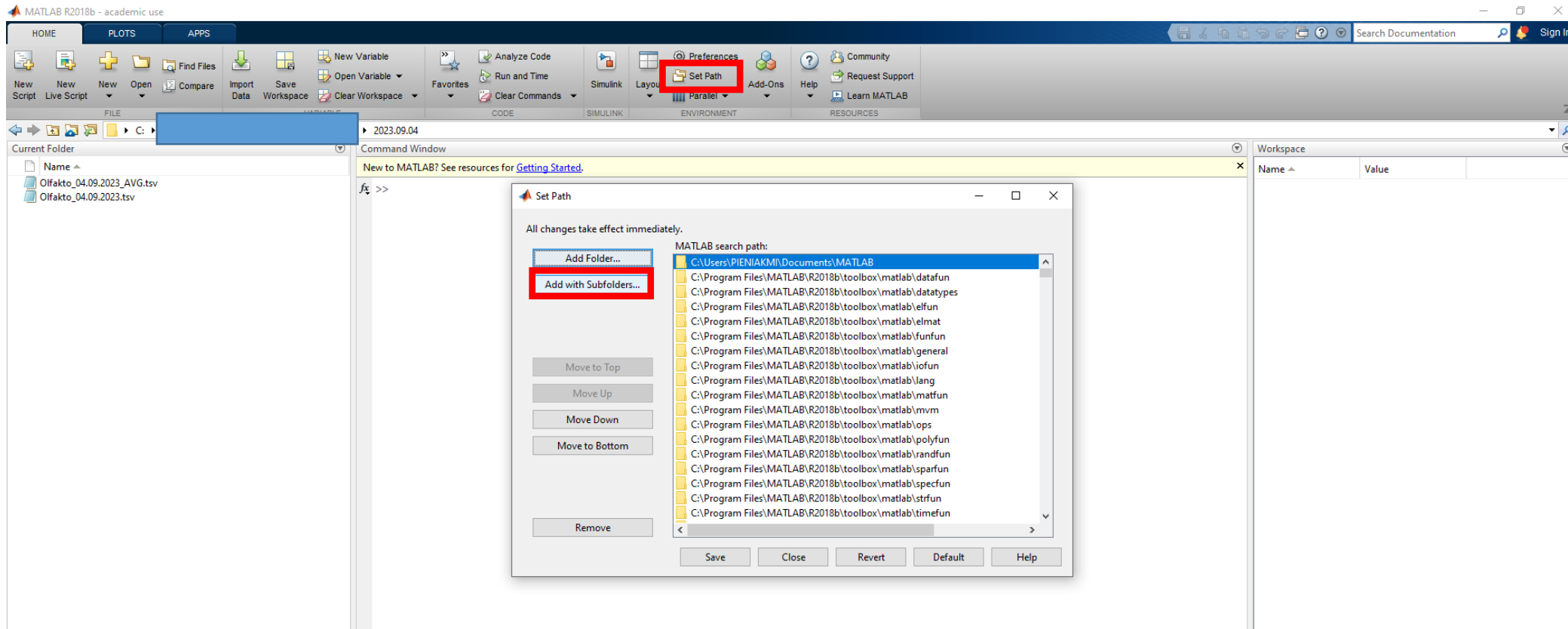
- Remove the first 500ms by marking the row A500 and using the combination Ctrl+Shift+Arrow Up



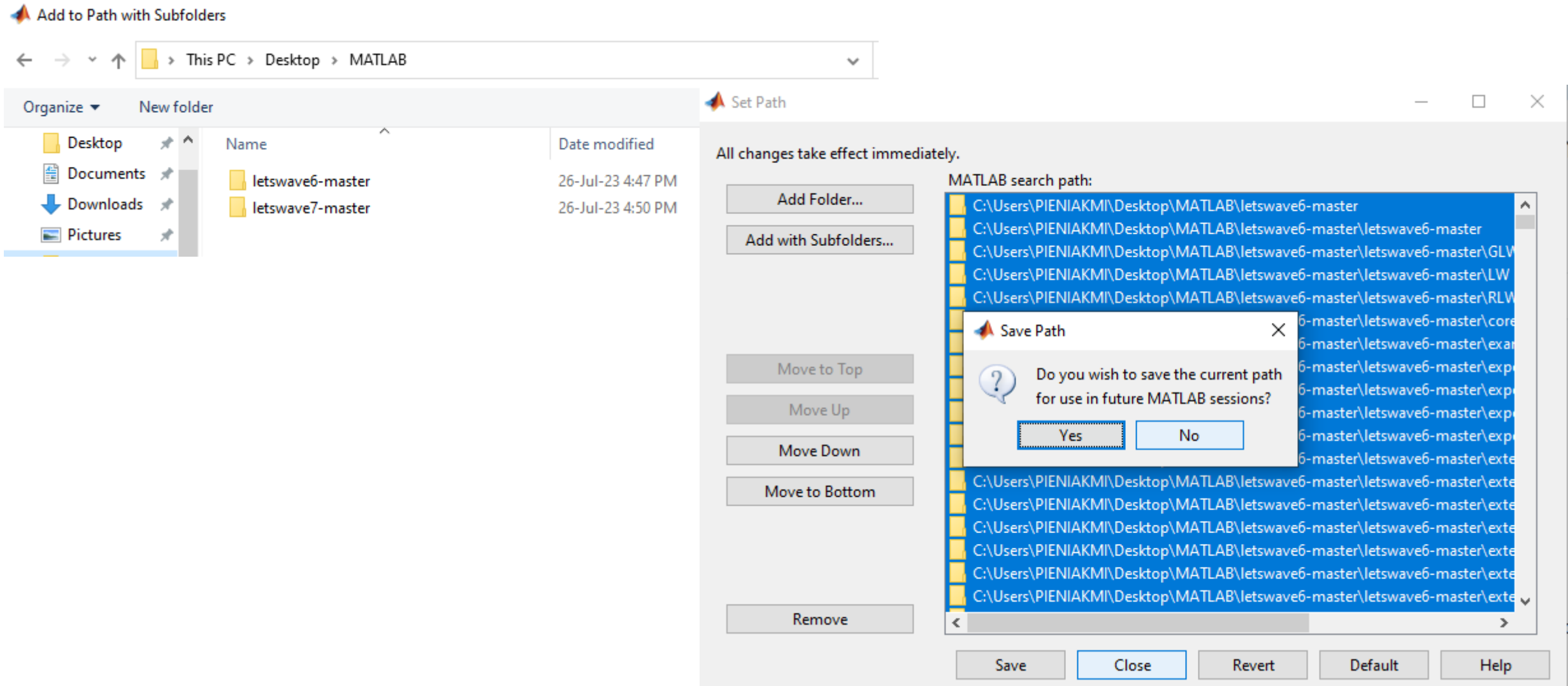
- Remove everything after 2500ms of the signal of interest (A2500) by using the combination Ctrl+Shift+Arrow Down (go to the end of the file)

3. Preprocessing in Matlab

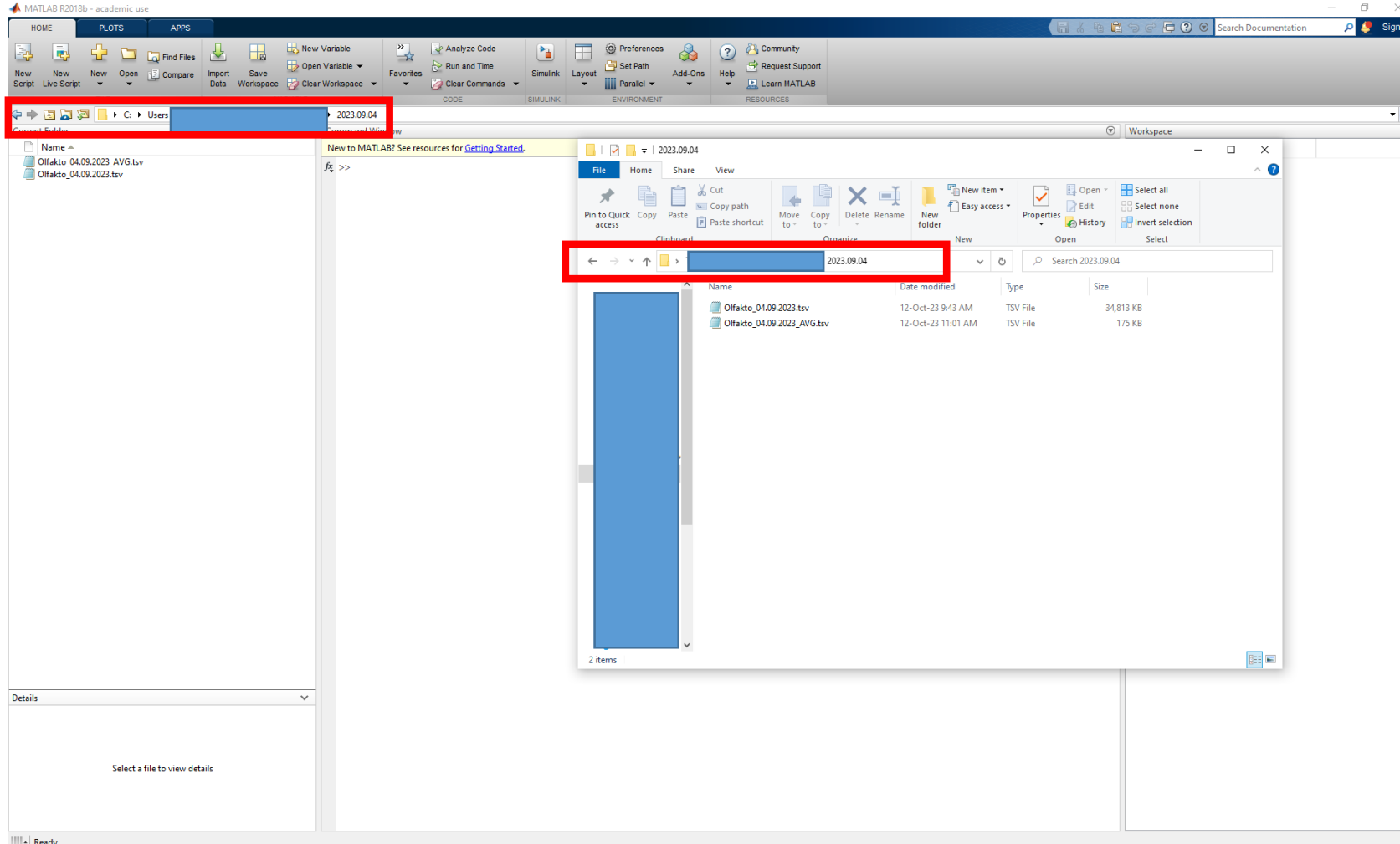
- For preprocessing we use Letswave program (ver. 6)
- To use letswave you need to set a path to the folder with the program



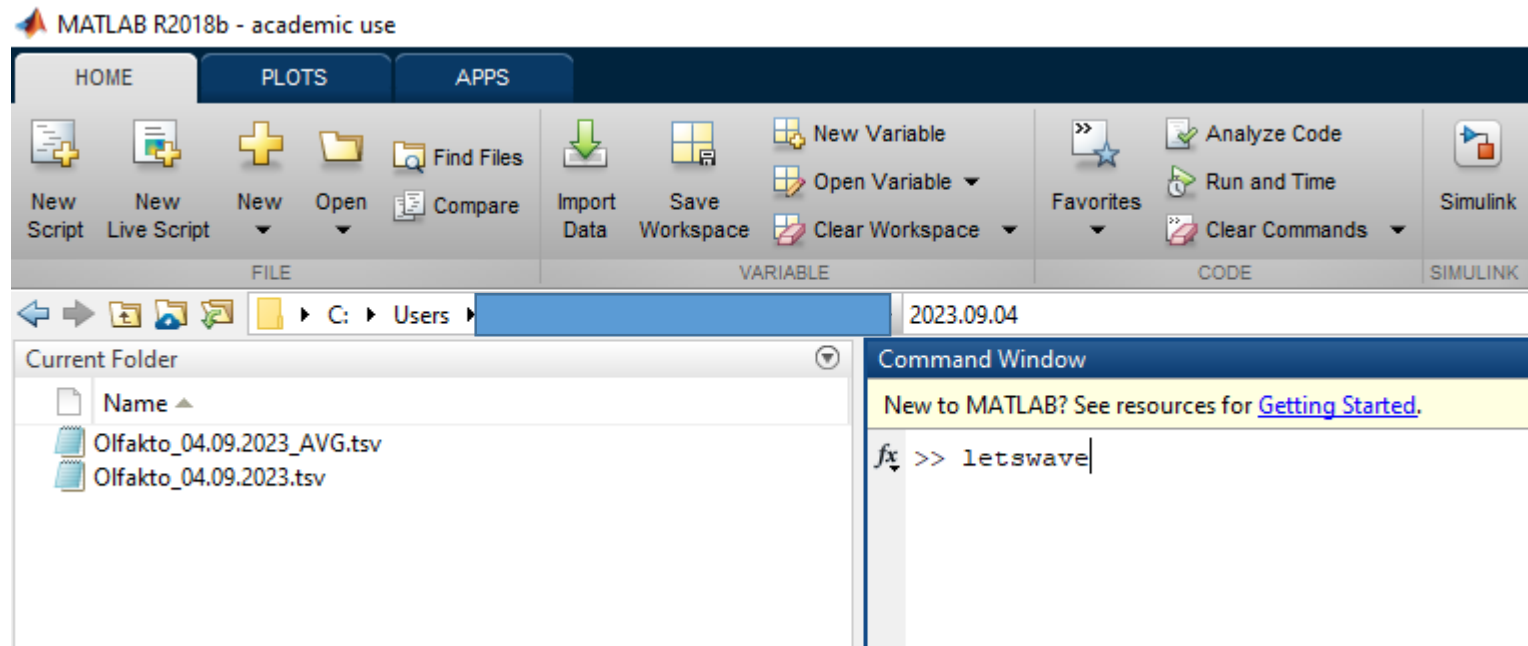
Select letswave6, close the window and do not save the path for future MATLAB sessions



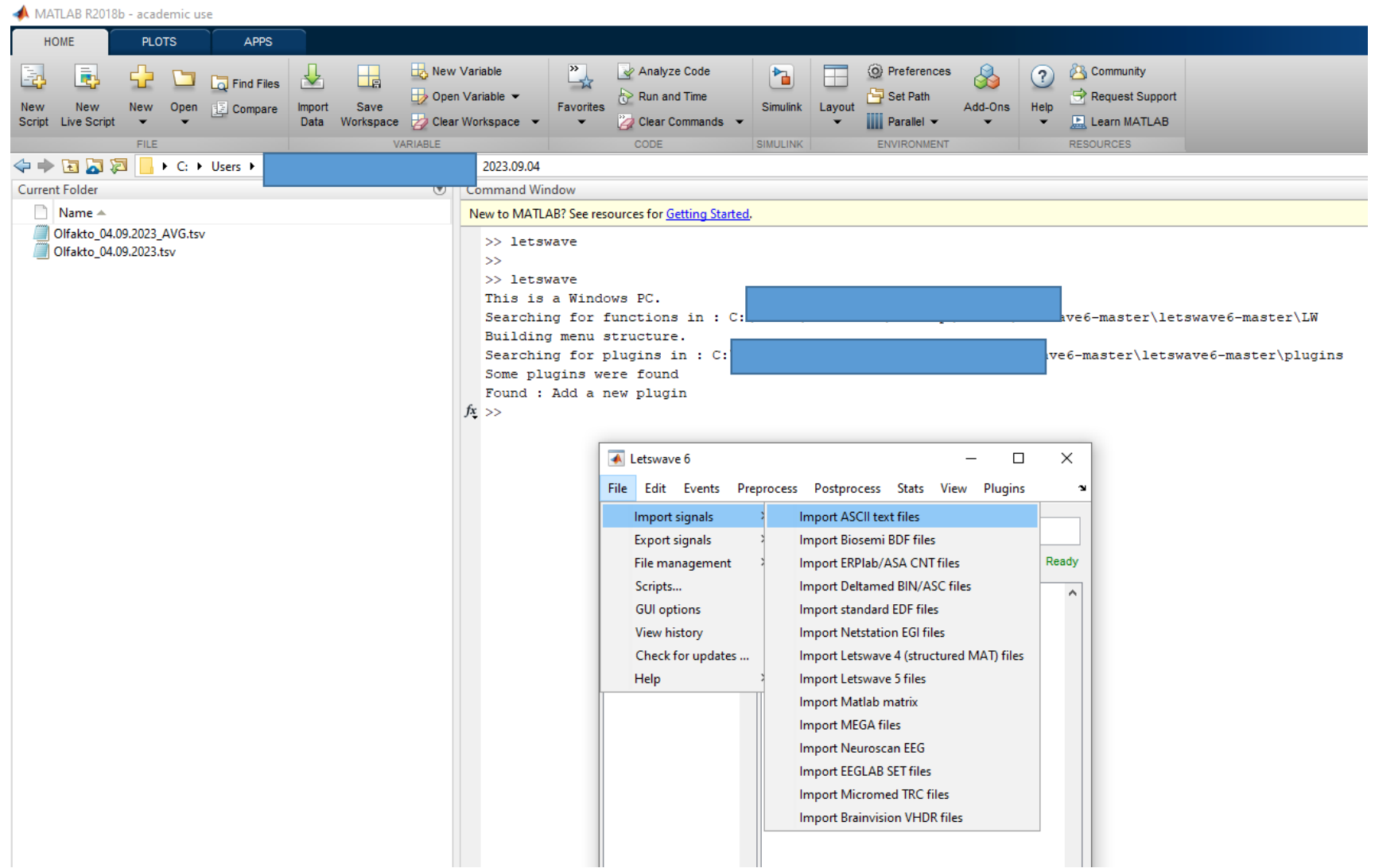
Make sure that Matlab file location matches the folder where your dataset is stored



Use command >letswave to open the program



Import the data to letswave using the following path



Select your clear .tsv file, choose tab column delimiter and change epoch size to 2500 (default is 1000). Click Process

Note: sometimes an error occurs at this stage, then you need to reload letswave again

import ASCII

Select files

Olfakto_04.09.2023_AVG.tsv

Header size (number of lines) : 0

☐ Import channel labels

Channel labels (line position) : 0

☐ Continuous data (one single epoch)

Epoch size (number of lines) : 2500

Samplingrate (Hz) : 1000

XStart (latency of first) : -0.5

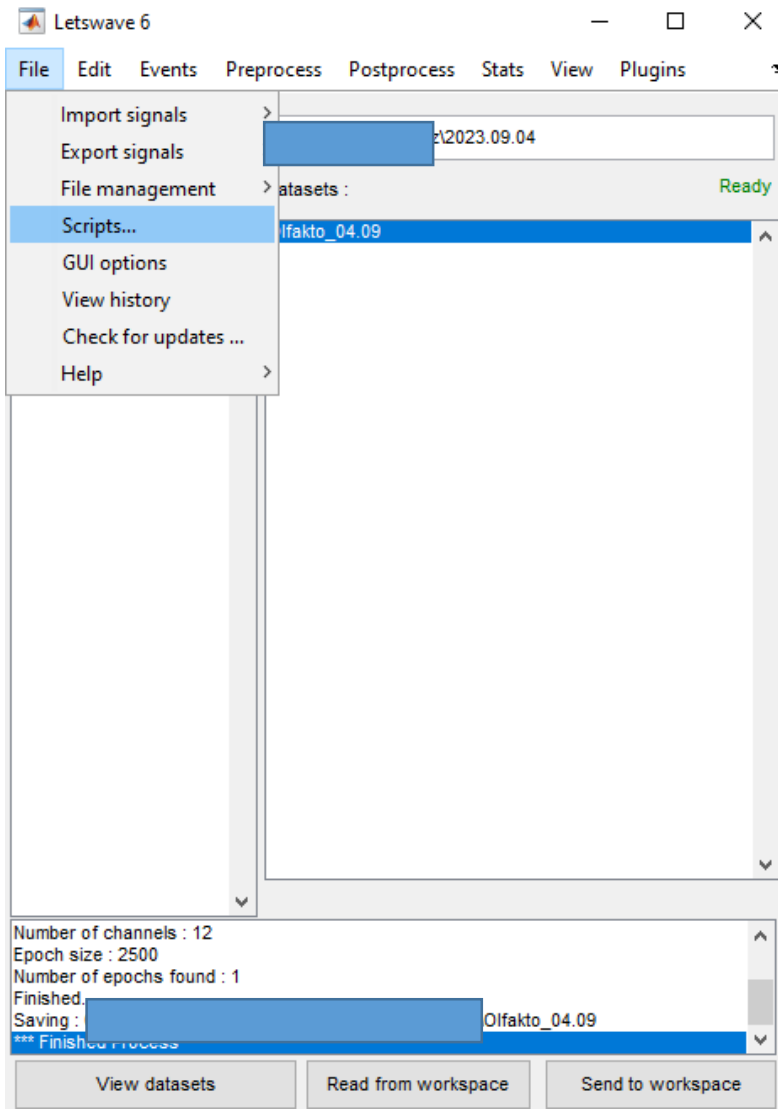
Column delimiter(s)

- space
- comma
- tab
- semicolon

Characters to delete from channel labels : ..

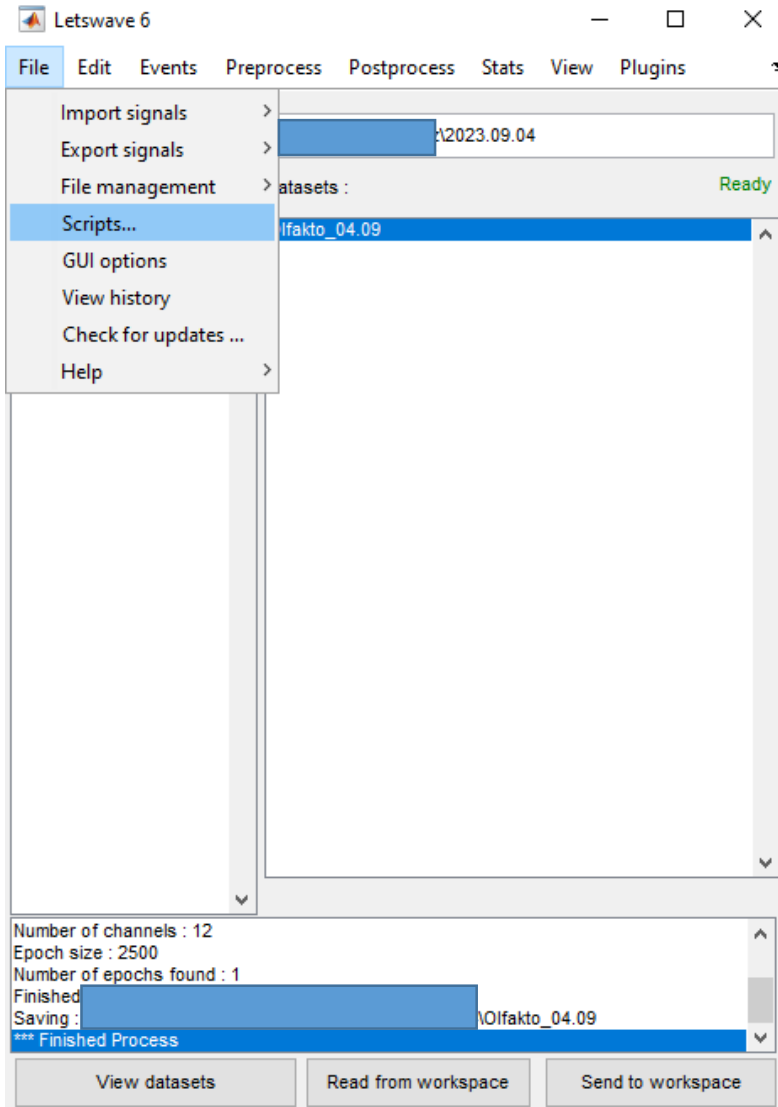
Process

We have two scripts prepared: 1. for averaging the signal and 2. time-frequency analysis



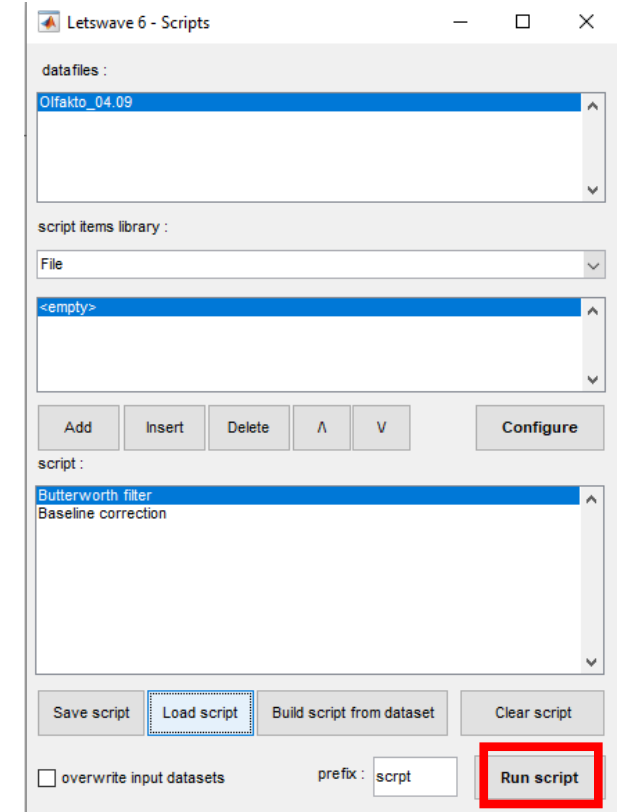
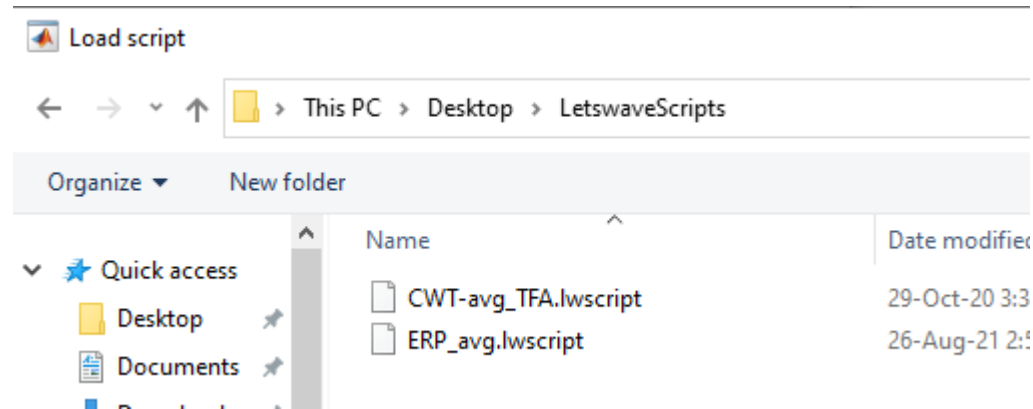
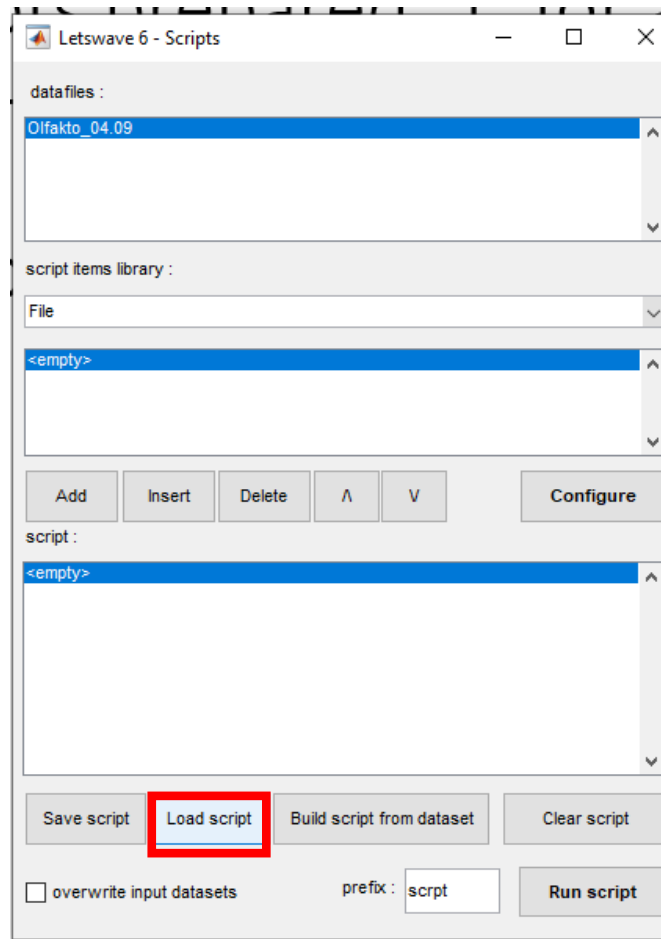
To use them, open File → Scripts

We have two scripts prepared: 1. for averaging the signal and 2. time-frequency analysis

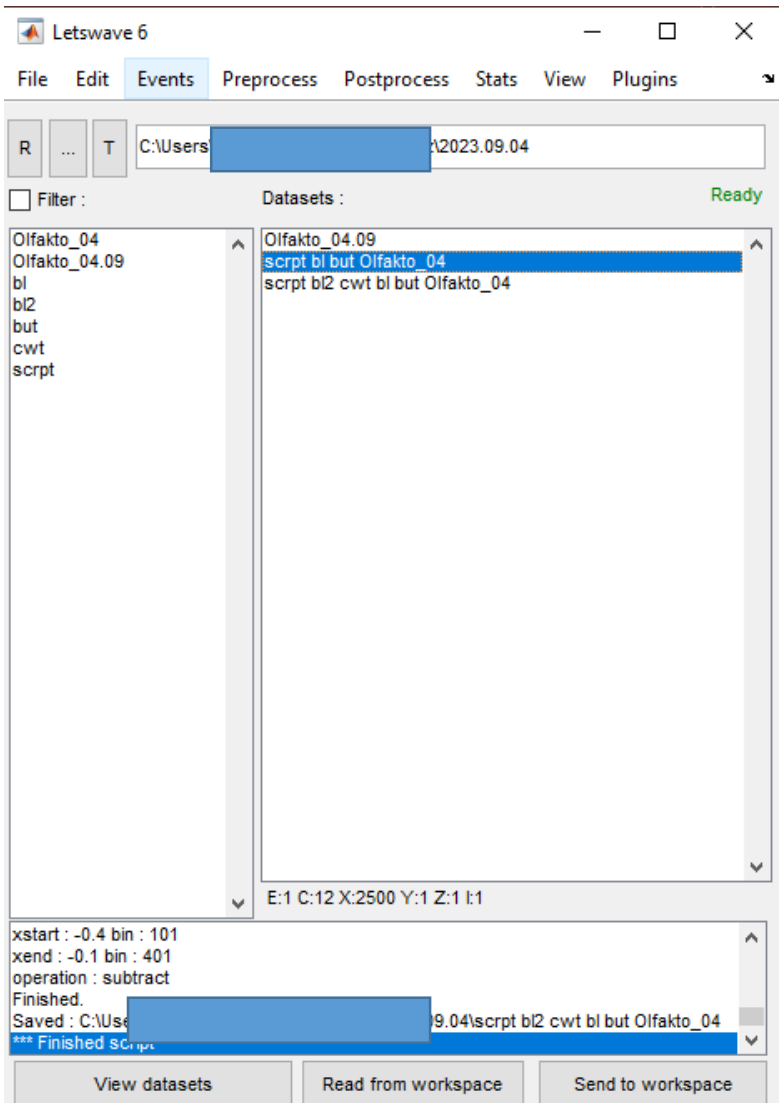


To use them, open File → Scripts

Load and run script (each script needs to be loaded separately)



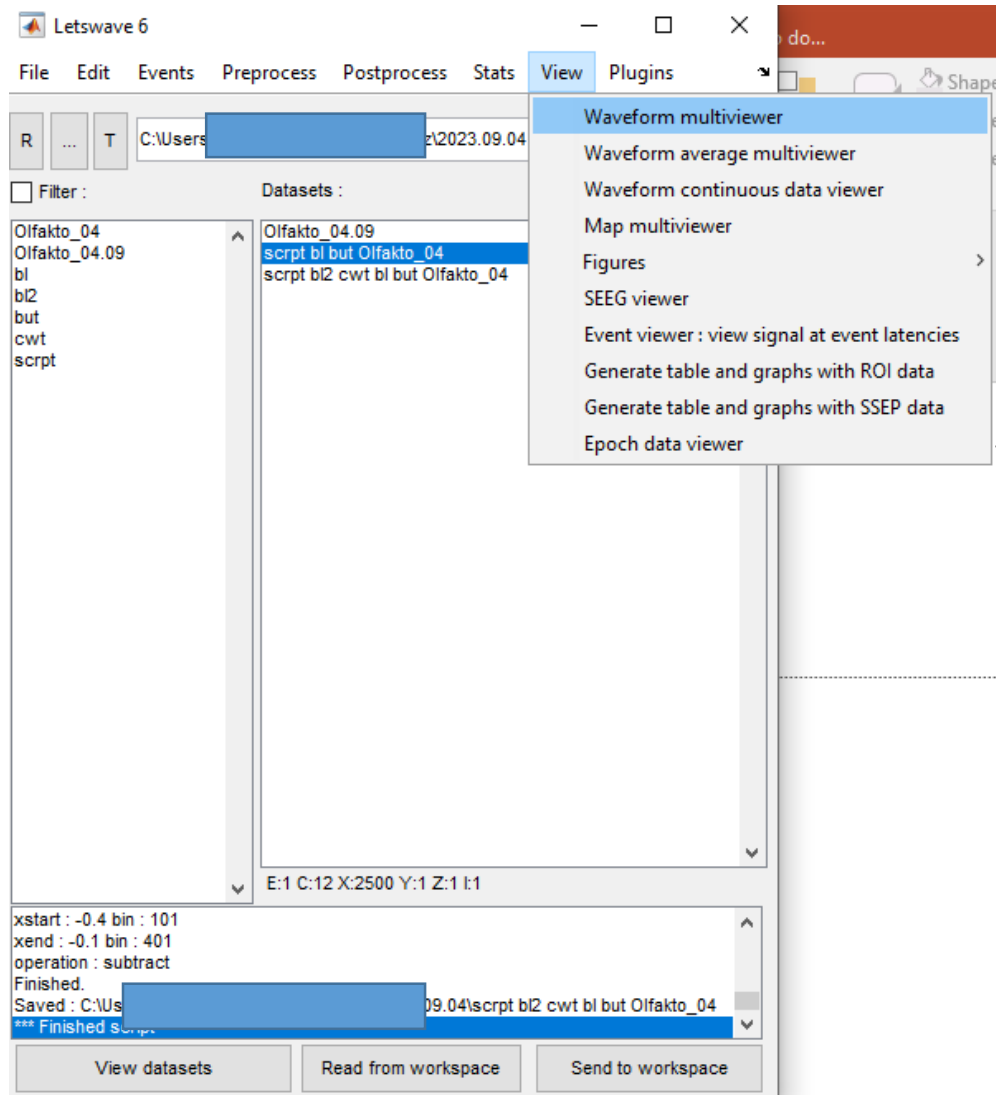
There are two new files in the workspace



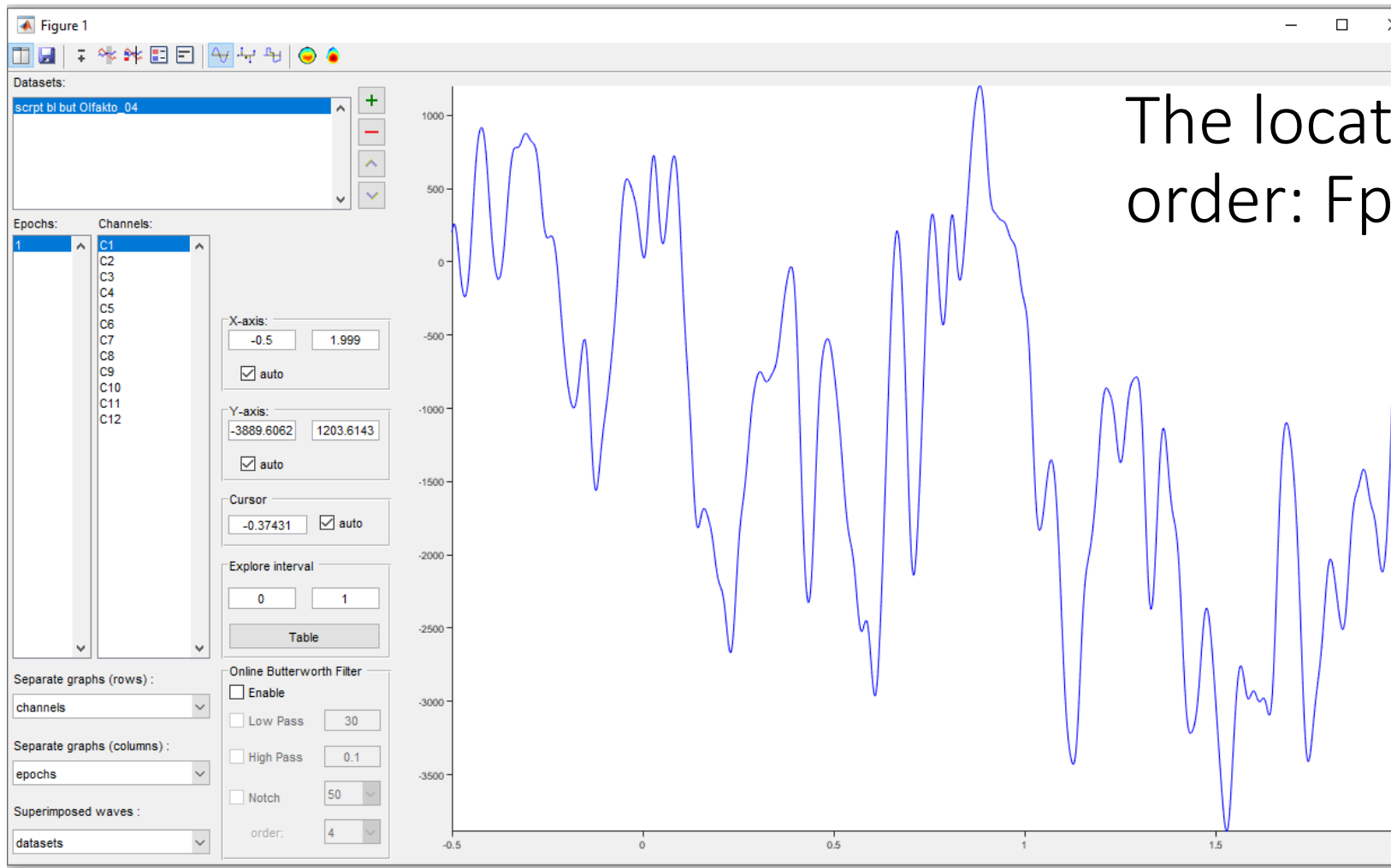
Scpt bl but → for averaged OERPs

Scpt bl2 cwt bl but → for time-frequency analysis

For OERPs → View -> Waveform multiviewer

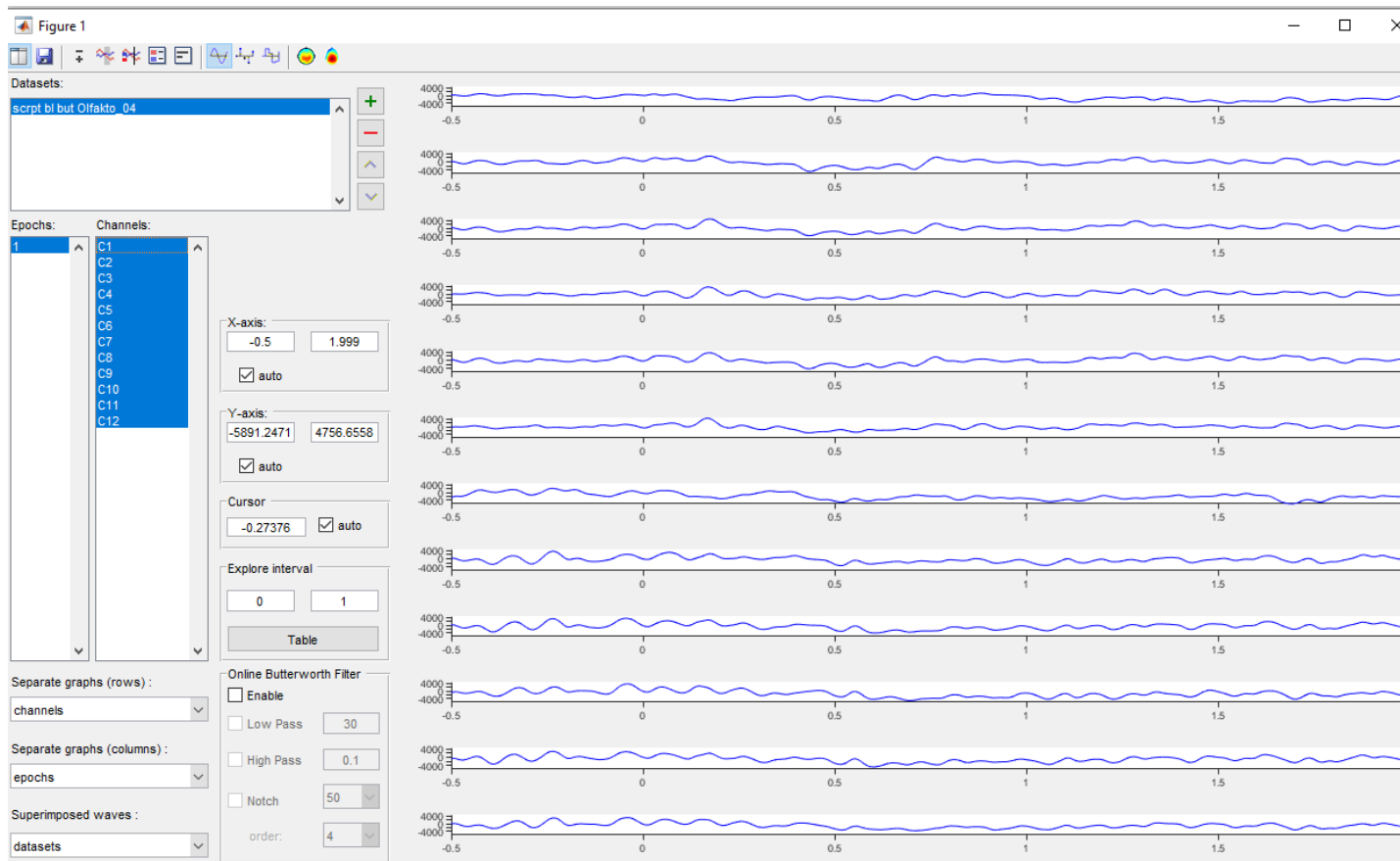


All the averages are visible now. There are 12 channels. First 6 channels are for Stimulus 1, channels 7-12 are for Stimulus 2.



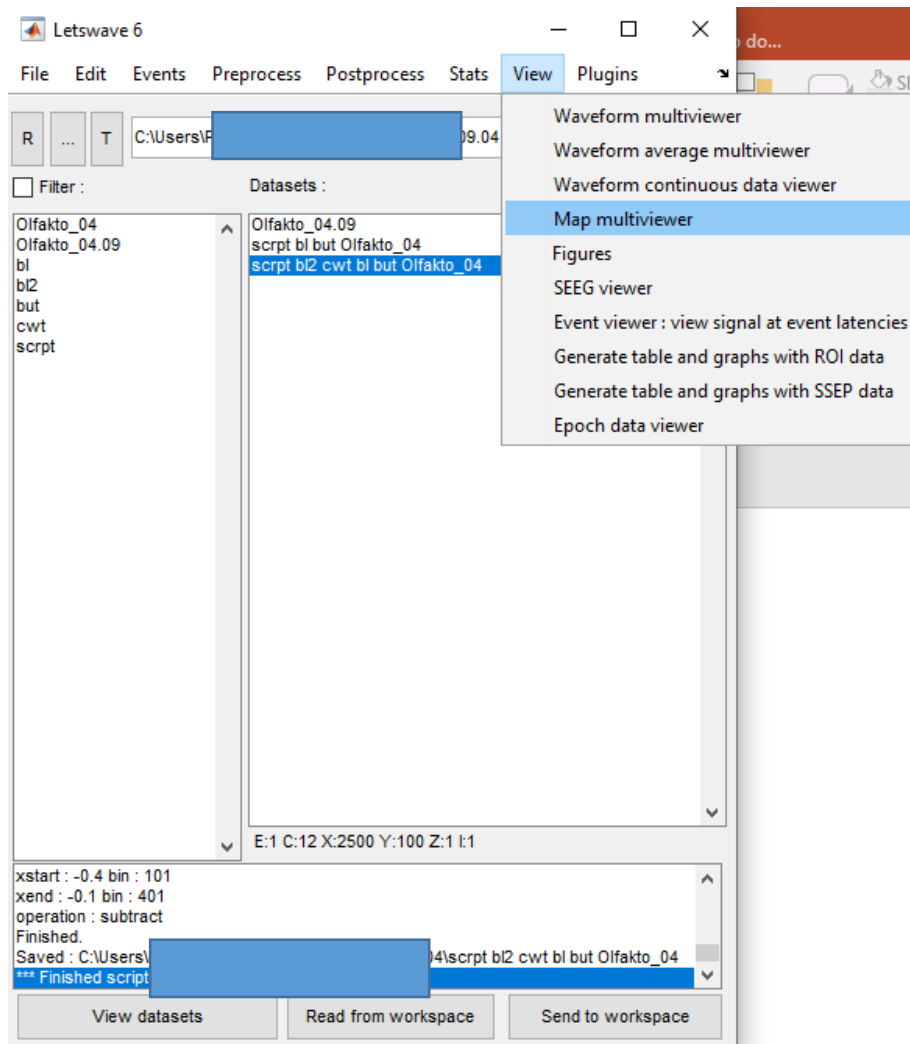
The locations are in the following order: Fp2, Fz, Cz, Pz, C3, C4

Select all the channels and set the Y-axis range to the same value for all of them



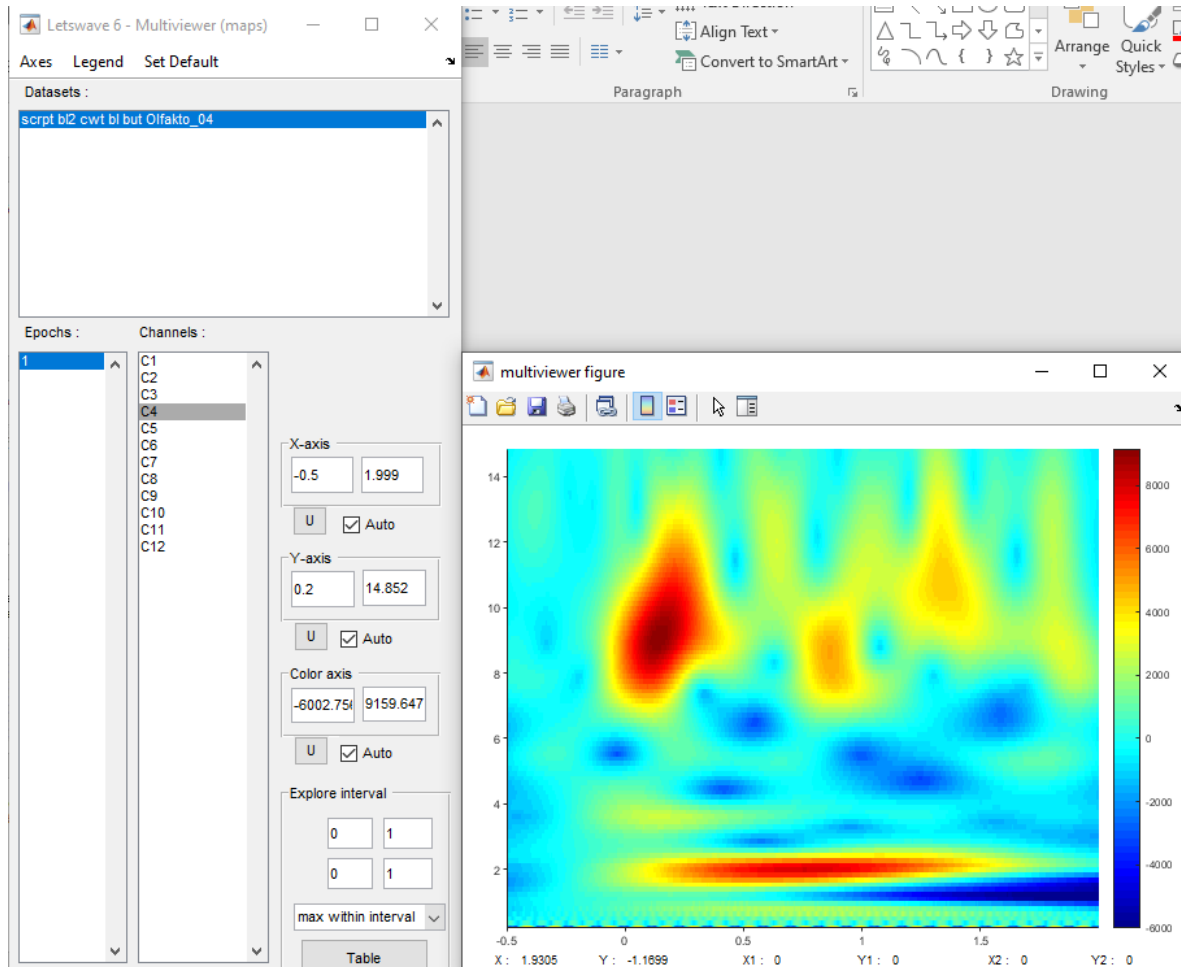
Now each of the OERPs might be saved for the final report (we use the Snipping tool and paste the images into the template)

To view the time-frequency maps: View: Map multiviewer



TFA we do for Pz location. These are channels 4 and 10.

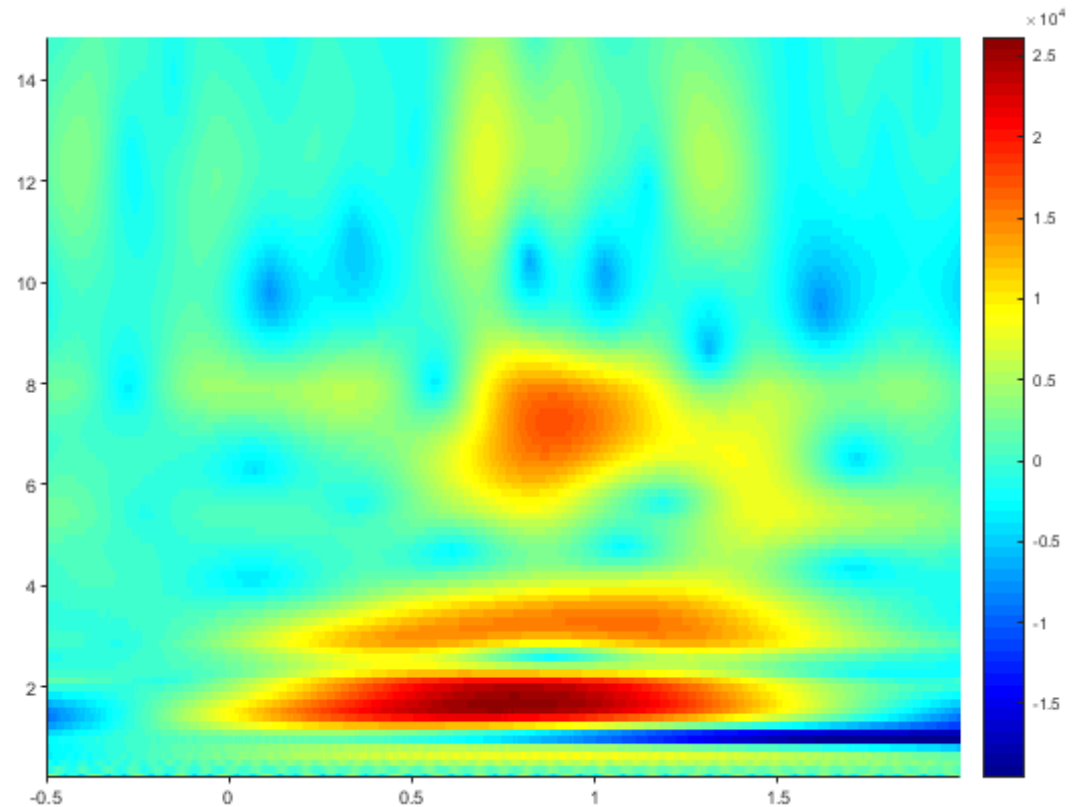
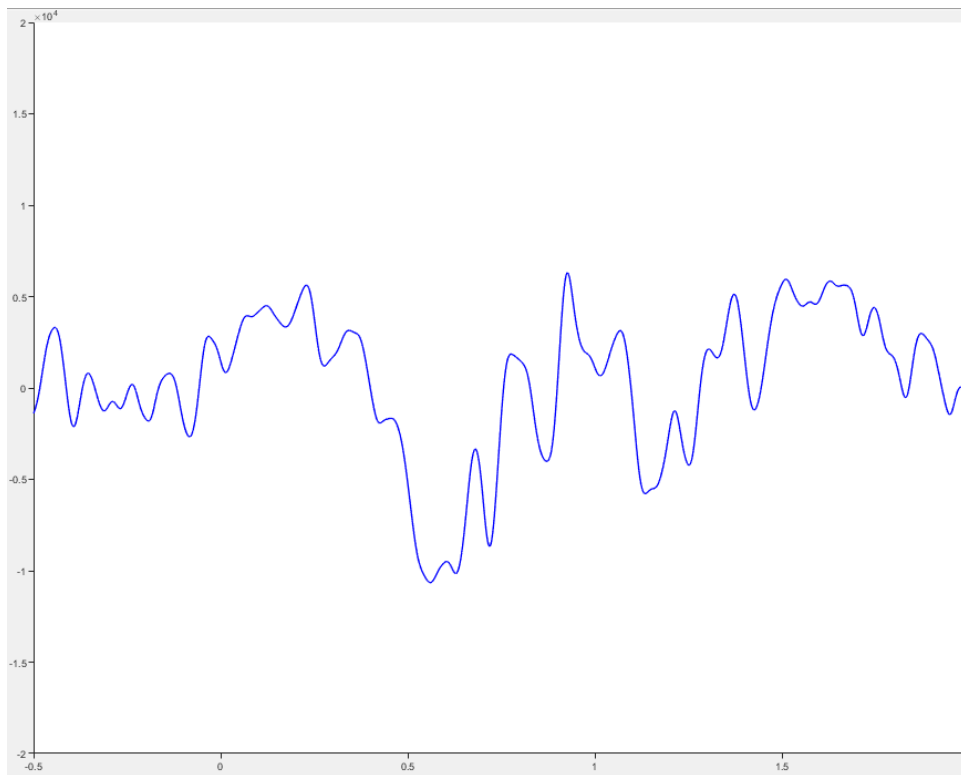
Select the channel and add the Color Legend.
Save the map using Snipping tool.



Template for reporting OERPs

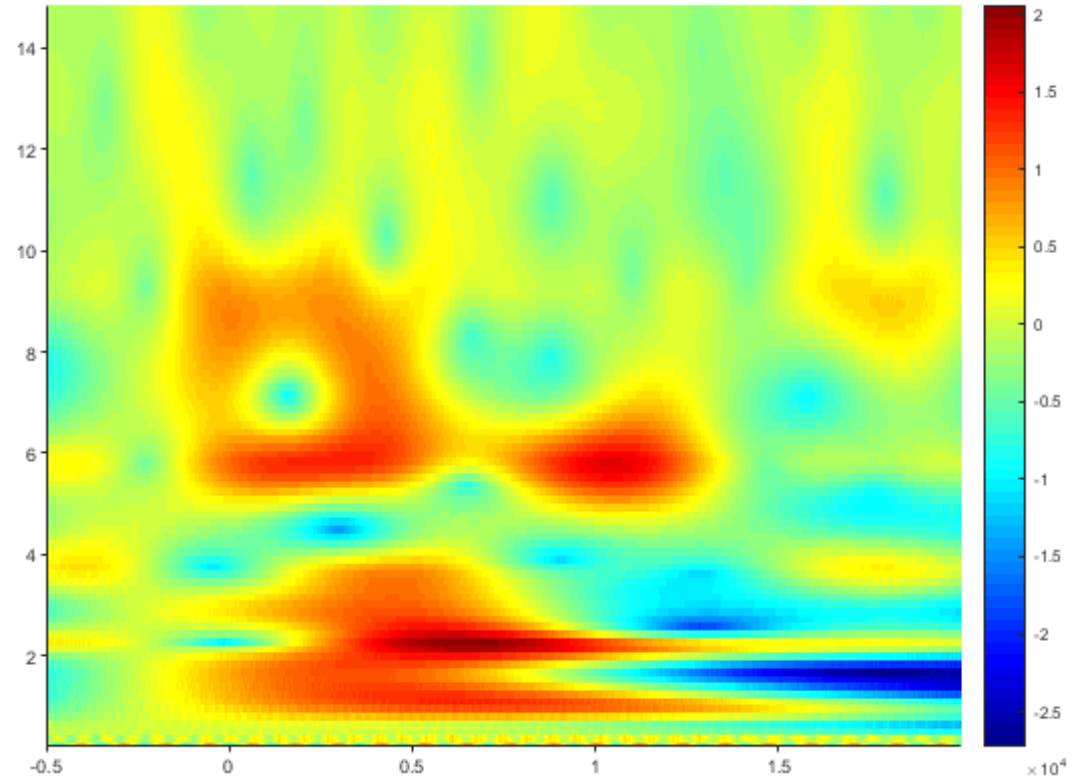
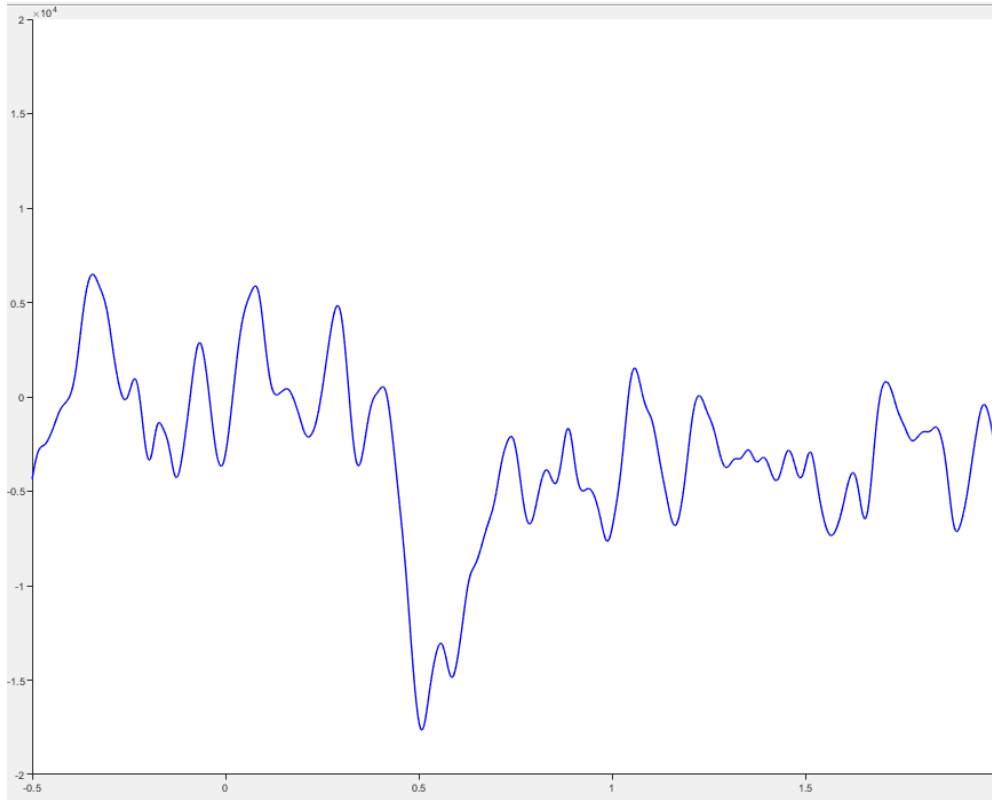
<p>1</p> <p>Time-frequency analysis from Pz</p> <p>Stimulus 1, n=</p> <p>Stimulus 2, n=</p> <p>Name, Date</p>	<p>Stimulus 2, n=</p> <p>Fp2</p> <p>Cz</p> <p>C3</p> <p>Fz</p> <p>Pz</p> <p>C4</p> <p>Name, Date</p>
<p>2</p> <p>Stimulus 1, n=</p> <p>Fp2</p> <p>Cz</p> <p>C3</p> <p>Fz</p> <p>Pz</p> <p>C4</p> <p>Name, Date</p>	
<p>3</p> <p>Stimulus 2, n=</p> <p>Fp2</p> <p>Cz</p> <p>C3</p> <p>Fz</p> <p>Pz</p> <p>C4</p> <p>Name, Date</p>	

Examples of OERPs showing olfactory responses, together with time-frequency view



OERPs should be visible around 0.5s after stimulus onset. In TFA low frequencies should be present.

Examples of trigeminal ERPs showing trigeminal responses, together with time-frequency view



Trigeminal ERPs should be visible around 0.5s after stimulus onset. In TFA low frequencies should be present.